Baconica, or the Natural Rarieties of England, Scotland, and Wales, according as they are to be found in every Shire." (London, 1660. 8vo.) The passage referred to in the *Examen désintéressé* we presume was taken from the Paris edition (1667. 12mo.), under Carnarvonshire (pp. 244, 245 of the French, pp. 147, 148 of the English edition). In his dedication he writes:—"The calling I have entred into, and the capacity * wherein I have the honour to serve your Lordship, wil (I fear) offend the weake tendernesse of some, who think these deep searches into reason misbecoming a Preacher of Faith, and the contemplation of the works of Nature very impedimentall (if not destructive) to the work of Grace," &c.

Stirling (whom his rival Clairaut calls "one of the greatest geometricians I know in Europe") enunciated without demonstration approximate propositions respecting the magnitude and the direction of the attraction of an homogeneous *oblatum* at its surface and *implicitly* (§ 156) established Newton's *postulate*.

We now proceed to give an account of the original work (not seen by Mr. Todhunter) entitled "Dégré du méridien entre Paris et Amiens." (Paris, 1740.) It has 6 pp. of contents:—lvi. pp. of Part I. in nine chapters, with 3 pp. of plates. Part II. is "Mesure de la terre" par M. l'Abbé Picard, 106 pp., with 10 pp. on Aberration of fixed stars, and 5 pp. of fixed plates. On p. vi. we find, "le dégré comparé à celui que nous avons mesuré au cercle polaire, que nous avons trouvé de 57437, 9 toises donne la terre aplatie vers les pôles; et le rapport de l'Axe au diametre de l'equateur, comme 177 à 178." We had some difficulty in finding the book in the Museum from Mr. Todhunter's description; at last we found it catalogued under the heading Picard.

The Museum copy of the Essay by Celsius (§§ 198, 739, not seen by our author), entitled "De Observationibus," &c., Upsaliæ, 1738, is bound up with several other tractates on our subject, but all the rest partake of the character of the ante-Newtonian writers. Thus Nicolaus Winterberg (1596) heads his chapters—"Rotundam esse (terram) liquido apparet;" "Terram cum aquâ conjunctam σφαιροειδην asserimus;" and he further maintains the earth to be the centre of system of universe. We need not give an analysis of Celsius's work here; for this is undoubtedly the original from which the German translation, discussed by Mr. Todhunter, was taken. He styles Newton "vir immortalis," and, deciding against James Cassini, thus ends his ten-page tract—"Spero itaque me jam æquo et candido lectori satis superque ostendisse observationes Cassinianas, tam cœlestes quam terrestres in Gallia præcipue meridionali habitas, adeo incertas esse et inde figura telluris nullo modo deduci queat."

We have now arrived at the period when the question between the Newtonians and Cassinians was decisively settled, and the victory of the *oblates* over the *oblongs* acknowledged even by the Cassinis. This result was brought about by the expedition to Lapland in 1736-37, and won for its ruling spirit, Maupertuis, Voltaire's witty compliment of having "aplati les pôles et les Cassinis."

R. TUCKER

(*To be continued.*)

OUR BOOK SHELF

Elements of Chemistry, Theoretical and Practical. By William Allen Miller, M.D., LL.D. Part II. Inorganic Chemistry. Revised by Herbert McLeod, F.C.S., Professor of Experimental Science, Indian Civil Engineering College, Cooper's Hill. 5th edit., with additions. (London: Longmans, 1874.)

IT will of course be superfluous to say anything in the way of criticism concerning this well-known manual. The death of its lamented author has necessitated the placing of the fifth edition in other hands, and it could not have fallen into better than those of its present editor. The principal changes so far have been a re-arrangement of the articles in accordance with the modern method of study and the removal of certain parts, such as those on gas analysis and the description of certain carbon compounds, to the appendix preparatory to their removal to the third part, to which they more strictly belong.

Some of the constitutional formulæ, now so much in use, have been introduced, and the kind selected have been those used by Frankland in his well-known "Lecture Notes." We are, however, glad to see that these have not been used to the exclusion of the notation adopted in former editions.

Great credit is due to Prof. McLeod for the thorough and conscientious way in which he has performed his task, and the only fault we have to find is that there is occasionally a certain amount of confusion caused by the use of different names for the same body, a fault for which, however, the science itself is largely responsible.

R. J. F.

Zones of Parallel Lines of Elevation in the Earth's Crust. By Angus Ross, sec. and mem. com. N. S. Inst. of Nat. Science. (Halifax, Nova Scotia, 1872.)

HE is a bold man who will predicate that no future discovered fact will disturb even the most widely accepted hypothesis. This being so, all hypotheses being in fact tentative only, and valuable in so far as they enable us to classify and deduce laws from such facts as we know, we ought to welcome every generalisation which groups known facts under some new aspect. In the above pamphlet we have such a generalisation. Whether it will prove to be supported by future discovery, or even whether it can be rigidly applied to explain actual facts will require much close criticism to determine. We can only say that it is ingenious and novel. The author claims to have discovered the method of distribution of the various mountain chains or lines of anticlinal elevation. These he asserts are arranged in parallel lines along certain belts or zones which girdle the earth, each zone following approximately the course of a great circle, and each having for its medial line or axis a line of volcanoes. Of these zones he describes seven, and we may extract one as a type of the rest. "Zone No. 1 on the Rocky Mountain system has its axial line in the volcanic belt extending from the middle Andes, inclusive, across Central America along the Rocky Mountains, Alaska, the Aleutian Islands, Kamtschatka, the Kurile Islands, Japan Islands, Loochoo Islands, Philippine Islands, Palawan, and Borneo. The Islands of Amsterdam and St. Paul, the Kerguelen Islands, the South Sandwich Islands, and South Georgia seem to indicate the completion of the more southerly part of the (approximately) great circle." The author, as we have said, describes seven such zones or belts which intersect one another, and argues that the points of intersection are foci of volcanic energy. He argues also that the great mountain-chains in their direction follow the course of one or other of these zones, and thus describes their arrangement:—"In each zone the proximity and elevation of the anticlinals diminish gradually from the axial line outwards, and if zone No. 1 be considered the most recent,

---

* He was chaplain to the "Rt. Hon. my most noble Lord and Master Henry Somerset Lord Herbert, &c."

© 1874 Nature Publishing Group

and the others as successively less recent in the order in which I have named them, and comparing similar parts of any two zones, the height of the anticlinals is greater, the dip less, and the difference between their axes greater in the more recent." The pamphlet is ably written and very deserving of study. HENRY H. HOWORTH

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

Animal Locomotion

IN NATURE, vol. ix. p. 301, there is a letter from Mr. Wallace on a very important point connected with the Theory of Flight. The question he discusses is "whether a bird's wing during onward flight moves *downwards and backwards* or *downwards and forwards;*" and Mr. Wallace supports Mr. Pettigrew in affirming that the movement is *downwards and forwards.*

As this is a subject to which I have paid long and close attention, I desire to express my conviction that neither of the two motions thus described by Mr. Wallace is the true motion of a bird's wing in forward flight.

The true motion is one strictly vertical to the axis of the bird's body; and as that axis is ordinarily horizontal in flight, the wing-stroke is a vertical stroke, that is simply downwards, and neither "downwards and forwards" nor "downwards and backwards."

This is not a question of theory, but a question of fact, to be determined by observation. The wing-stroke of most birds is indeed so rapid that the eye cannot distinctly follow the operation. But there are birds whose wing is so large and whose flight is so slow, that the wing-stroke can be followed with the greatest distinctness. Such is the common heron—common, alas, no longer in most parts of England, but numerous on the west coast of Scotland. When at home I am in the daily habit of watching their flight; and the truly vertical character of the wing-stroke is a fact which I have verified by the eye under every possible condition which could supply the evidence.

There are indeed two slight modifications of the perfect perpendicularity of the stroke which result (1) from the attachment of the wing to the body of the bird, and (2) from the structure of the wing-feathers. The first of these two modifications consists in this—that as the wing moves upon a hinge, its extremity must move downwards, not absolutely vertically, but describing an arc. The segment of a circle, however, through which the wing thus moves, is generally a very short one: and in so far as the movement of the extremity departs from the vertical, it departs therefrom neither "backwards" nor "forwards," but (as it were) "inwards,"—that is, in the direction of a circle encompassing the axis of the bird's body as with a hoop. Pigeons, as an amusement and in play, often complete this circle—making their primary quills clash against each other over their backs, and downwards again under their breasts. But in ordinary forward flight, when birds are intent only on progression, the wings move through a very small arc indeed of the complete circle referred to.

The second modification of the perpendicularity of the stroke arises from the "set" of the wing-feathers—which curve backwards and downwards from the wing-bones. In some birds, and notably in the heron, and all the storks, the concavity thus formed is very deep, and of course a surface which is thus not a plane surface, but a concave one, however truly it may be struck downwards, cannot have a purely vertical reaction on the air.

When we observe, however, that in the case of many birds, and some of these the most powerful fliers in the world, this concavity of the wing-feathers is very slight indeed, and that the whole vane is very narrow, flat, and "taut," it is obvious that a purely vertical stroke, or one as near it as possible, is the really essential stroke for flight.

The great secret of flight is the exquisite and complicated adaptation of structure in the feathers of a bird's wing which derives from this one simple action the resultant of a force which is both sustaining and propelling. It is an adaptation which, when thoroughly grasped and understood, at once dispenses with as needless, and condemns as mechanically erroneous, all the explanations which assume either a "downward and forward" or a "downward and backward" movement.

I venture to think that Mr. Wallace is certainly in error when he ascribes to Mr. Pettigrew the merit of having been the first to show that "horizontal forward motion is a general resultant of the upward and downward action of the wings under the influence of gravitation."

In February 1865 I published in *Good Words* a paper on the mechanism of flight, in which this effect of the wing-stroke was fully explained, and elaborately illustrated. This paper subsequently appeared as chap. iii. in the "Reign of Law" published in the end of 1866. Mr. Pettigrew's lecture before the Royal Institution (in which I believe his views were first promulgated) was delivered on March 22, 1867. I had the pleasure of hearing that lecture, and the amusement of recognising parts of it (including even a poetical quotation) as taken directly from my chapter on flight. The pleasure, however, was somewhat abated by the strange mixture of much that was quite correct, with a great deal more which I believed then, and believe now, to be wholly erroneous. ARGYLL

March 11

MR. WALLACE has well said that the question, How a bird's wing moves in flight, "is a very important question." In these days, when scientific attention is being directed to the problem of aërial navigation, it is especially important. I have the less hesitation, therefore, in troubling you with some further remarks in reply to the strictures of this very accurate observer.

At the outset I must deny that I assumed either that a bird's wing is inflexible or that it is a plane. Of its flexibility I had no cause for speaking at all; but so far from regarding it as a plane, I expressly objected to Dr. Pettigrew so representing it in his supposed refutation of the orthodox view. The point in dispute is entirely concerning the down stroke; against Mr. Wallace's account of the up stroke I make no objection.

First, what may we infer *à priori* concerning the down stroke? (1) Its efficiency is independent of the velocity of the bird: this is simply a consequence of the second law of motion. We have to suppose a bird fixed in still air, and to ascertain the effect which ensues on a downward blow of the wing. The subsequent forward velocity of the bird, so far as that depends on the down stroke, is but a consequence or an accumulation of these effects. It is thus only needful to analyse the single effect itself. To this end the shape and varying flexibility of the wing must be noted. Along the exterior margin we have a rigid area, comparable to the blade of an oar, and formed for the most part of bone, in the *top side* of which the rigid tubes of the primary and secondary feathers are inserted. On the under side of this, which we may term the oar part of the wing, there is thus a considerable concavity, the direction of which when the wing is extended is decidedly backward. The area towards the middle line of the wing is flat and horizontal, approximately so at all events, when the bird is freely suspended in the air. Of the posterior, the larger, half of the wing it is true, as Dr. Pettigrew says, that the aspect is forward, more especially in heavy birds with broad and rounded wings. The flexible extremities of the feathers readily turn upwards like vanes in the manner so well shown in Fig. 80 of Dr. Pettigrew's work. We may thus roughly distinguish four areas, beginning from the front: (*a*) the oar area; (*b*) the plane or flapping area; (*c*) the kite area; (*d*) the vane area. (2) Now we may inquire what will be the effect of each when the wing is struck downward. The reaction from the oar area will be (*a*) a force directed upwards and forwards; that from the plane area (*b*) a force directed upwards simply. Against the kite area will impinge the air sent backwards and rebounding from the blow of the oar area; the effect of this (*c*) is all that corresponds to what Dr. Pettigrew calls the kite action of the wing. Lastly, the same air in escaping through the feathers, and especially in raising the tips in the vane area, will produce the forward motion (*d*) to which Mr. Wallace refers, besides contributing something (*e*) to support the bird's weight. The horizontal component of (*a*) together with (*d*) will carry the bird forward. The slighter horizontal component of (*c*)—slighter because proceeding only from the rebounding air and from a yielding surface—will tend to hinder the forward motion: hence the absence, more or less complete, of this area in quick fliers. The forces (*b*), greater part of (*c*), and (*e*) will sustain the bird against gravity.

Neither Dr. Pettigrew, nor apparently Mr. Wallace, distinguishes the motion consequent on a surface striking against the air from that of a surface gliding through it. If I incline a sheet of paper to the horizon and let it slip from my hand it will descend with a similar incline towards the ground; but if, having stiffened it, I strike it against the air at the same inclination it will tend to rise in a direction at right angles to that inclination. The *blow*

© 1874 Nature Publishing Group